TABLE 1. Characteristics of patients and data of recurrence, metastasectomy, survival time

Patient	1	2	3	4	5
Gender	Male	Male	Male	Male	Male
Age, y	49	66	47	63	37
Thoracic recurrence					
Location	RUL, RLL	RLL	RCC, RLL	RML	RUL
Size (cm)	1, 2	3.5	5, 0.5	3	1
Resection	Wedge	Lobectomy	Rib resection, Lobectomy	Wedge	Wedge
Tumor differentiation grade	Low, low	Low	Low, benign	Low	Low
Postresection treatment	No	No	No	No	No
Secondary recurrence	No	Yes	No	No	No
Location	—	Left adrenal gland	—	—	—
Size (cm)	—	3	—	—	—
Resection	—	Laparoscope	—	—	—
Tumor differentiation grade	—	Low	—	—	—
Postresection treatment	—	No	—	—	—
Alive	Yes	Yes	Yes	Yes	Yes
Time from transplant (mo)					
to thoracic recurrence	32	33	12	8	11
to secondary recurrence	—	39	—	—	—
Survival time from TRR (mo)	53	16	8	9	3

RUL, Right upper lobe; *RLL*, right lower lobe; *RCC*, right costal cartilage; *RML*, right middle lobe; *TRR*, thoracic recurrence resection.

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Radio-guided surgery for ventricular remodeling in patients with ischemic dilated cardiomyopathy: A new tool to discriminate in vivo viable myocardium and scar

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Acombined surgical procedure, left ventricular restoration (LVR), which consists of coronary artery bypass grafting and endoventricular patch plasty (EPP), is under investigation in the on-going Surgical Treatment for Ischemic Heart Failure trial.[1] EPP can provide restoration of left ventricular (LV) size and geometry by excluding nonviable areas. At present, the differentiation of viable tissue and scar tissue is based on using subjective methods to assess morphologic features, such as consistency, thickness, and color of the wall, and it might be inadequate on the surgical table. We assessed the feasibility of in vivo radio-guided surgery (RGS) with a gamma probe as an objective tool to differentiate viable tissue and scar tissue in patients undergoing EPP.

CLINICAL SUMMARY

Two patients with previous anterior myocardial infarctions were selected for LVR (Table 1). Informed consent

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TABLE 1. Demographic data and clinical characteristics of the patients

	Patient 1	Patient 2
Age (y)	62	63
Sex	Male	Male
Prior myocardial infarction	Anterior	Anterolateral
Angina	Yes	No
Left ventricular ejection fraction (%)	20	35
NYHA class	III	III
Grafts (n)	1	3

NYHA, New York Heart Association.

and the approval of the local ethics committee were obtained. One week before LVR, patients underwent gated single-photon emission computed tomography (SPECT) with Tc-99m sestamibi to assess myocardial perfusion and LV function.[2] Twelve hours before LVR, the same imaging protocol was repeated for the in vivo analysis of tracer distribution during EPP. RGS was performed with a gamma probe (Breast Care Unit; Neoprobe Corp, Dublin, Ohio) with a spatial resolution of 3 mm.[3] SPECT was repeated 6 months later to assess the effects of LVR on myocardial perfusion and LV function.

Both patients underwent LVR, according to the procedure of Dor and colleagues.[4] After cardiac arrest, the scarred/viable junction was evaluated in conjunction with the standard approach, based on subjective patterns, by means of a continuous counting rate of gamma radiation measured in counts per second and updated every half-second. Tissue characterization with the gamma probe was performed both on epicardial and endocardial LV surfaces after incision of the necrotic anteroapical wall segment (Figure 1). Thereafter, an encircling suture at the scarred/viable junction was obtained to exclude the fibrotic segments from the ventricular cavity, creating an approximately 3-cm pursed opening. In the end, an oval synthetic patch closed the ventricular opening, folding the excluded scar over the patch to ensure hemostasis.

At presurgical SPECT, in both patients the lowest tracer uptake was observed in the anteroapical region (15% of peak activity in patient 1 and 12% in patient 2). LV function in patient 1 is shown in Figure 2. In agreement with presurgical SPECT, a similar pattern was observed at the gamma probe, with the lowest count rate being approximately 30 to 40 cps. The surgeon also deemed these segments, using subjective standard methods, to be the center of the LV nonviable area. By using the gamma probe, 2.5 up to 6 ratios between viable and necrotic myocardium, as visually defined by the surgeon, was determined in both patients. Such a different count rate increased the surgeon's self-confidence to trace the borders between the scar tissue and viable tissue. The highest value of viable/necrotic count ratio was observed with the probe inside the ventricular chamber, laying on the endocardial surface, and away from the patient's

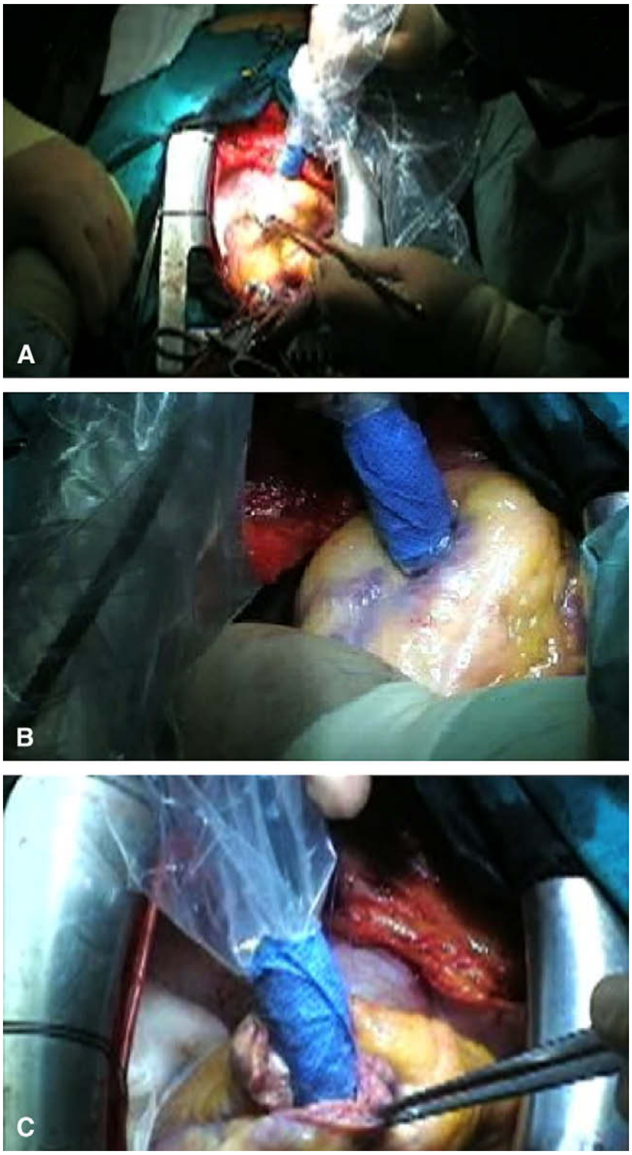

FIGURE 1. Radio-guided surgery during left ventricular remodeling. In vivo analysis of tracer distribution for the differentiation between viable tissue and scar tissue was performed on the epicardial (A and B) and endocardial (C) surfaces of the ventricular chamber.

background. Conversely, high background levels of up to 350 cps were recorded when the probe in contact with the epicardial surface was directed toward the subdiaphragmatic organs, mainly related to bowel radioactivity. The whole procedure did not require significant time on the surgical table, being less than 5 minutes for both patients.

SPECT performed 6 months after LVR demonstrated a reduction in the extent and degree of perfusion defects in both patients. An improvement in ejection fraction was observed in both patients (from 21% to 43% in patient 1 and from 36% to 53% in patient 2). Postsurgical LV function in patient 1 is shown in Figure 2.

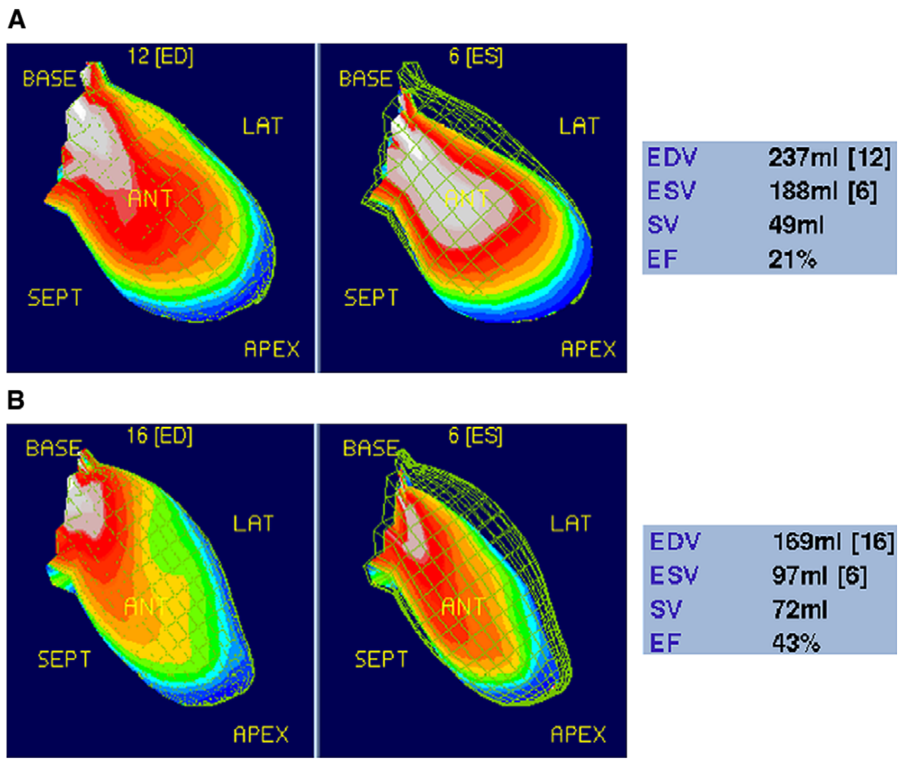

FIGURE 2. Presurgical (A) and postsurgical (B) left ventricular volume in end-diastole *(EDV)* and end-systole *(ESV)* in patient 1. Restoration of ventricular size and shape resulted in an improvement in stroke volume *(SV)* and ejection fraction *(EF)*.

DISCUSSION

This is the first report demonstrating the feasibility of RGS with labeled cardiac perfusion agents. RGS allowed us to reach an effective difference in count rates deriving from viable tissue and scar tissue. The surgeon reported an improvement in his self-confidence for defining transitional zone between scar and viable tissue with respect to the standard approach. Furthermore, RGS did not affect the duration of the surgical procedure. The therapeutic efficacy was documented in both patients. In fact, the extent and degree of perfusion defects and of areas of akinesia were reduced after RGS.

Over the last decade, RGS has undergone continuous growth, with application in several fields, mostly related to malignant diseases. RGS implies the use of a gamma-probe to count the radioactivity derived by tissues concentrating the administered tracer. Because of the high spatial resolution and sensitivity, gamma probes are able to detect small sources of radioactivity and to distinguish radioactive tissue from close areas without significant uptake of gamma emitters.[3] Cellular uptake and retention of myocardial perfusion agents, such as sestamibi, are expressions of preserved myocyte viability.[2] Conversely, necrotic or fibrotic areas are unable to extract and retain the tracers.[5] On this basis, the gamma probe provides the possibility to characterize viability in vivo.

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